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XVI.

THE MAGNETISM OF NICKEL AND TUNGSTEN ALLOYS.

By John Trowbridge and Samuel Sheldon.

Presented May 28, 1889.

Introductory.

The fact that different kinds of steel, alloyed in small proportions with Tungsten or Wolfram, and magnetized to saturation, increase in specific magnetism,* has long been known. Whether the same effect would result from the use of Nickel alloyed with Tungsten has never been investigated. This paper has for its object a partial answer to the query. It was instigated by Mr. Wharton, proprietor of the American Nickel Works, whose chemist, Mr. Riddle, kindly prepared the alloys which have been employed. These alloys were in two groups. The first, received in November, 1888, consisted of three bars of the same shape, one being of pure nickel and the other two having respectively 3 and 4 per cent of tungsten in alloy. These bars were rolled from cast ingots, which were toughened by the addition of magnesium after Fleitmann's method, the magnesium being added just before pouring. They were hot when rolled. The one of pure nickel was afterwards planed into regular shape. Those containing tungsten were too brittle to allow of this manipulation. They were, however, of sufficient regularity to permit accurate measurements. This group contained also an octagonally shaped bar with 8 per cent of tungsten, which was prepared like the others, and was afterwards ground into shape.

The second group, received in May, 1889, contained bars which were simple castings, made without the addition of magnesium, and consisted of pure nickel and alloys with 1, 2, 3, and 6 per cent of tungsten. All the bars in this group were extremely hard and brittle. In making them, tungsten oxide, of weight calculated to yield the desired percentage of tungsten in the resulting alloy, was placed with adequate carbon in the bottom of a graphite crucible and covered by the proper weight of pure grain nickel. All was then covered with borax, the lid of the crucible was placed on, and the crucible was heated until reduction and fusion were completed.

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* Jour. Chem. Soc., 1868, xxi. 284, says 300 per cent.

METHOD.

As the suspected influence of the tungsten would be to affect the magnetic moment of the bars, these were magnetized to saturation and their specific magnetism then determined, i. e. the magnetic moment for each gram of metal.

The magnetization was effected by placing the bars separately in a hollow coil whose length was 15 cm. and outside and inside diameters respectively 6 and 3 cm. It consisted of 6 layers of wire having 63 turns each. A dynamo current of 40 ampères was then sent through the coil for one minute, and the circuit then broken and the bars removed.

For the determination of the magnetic moment, use was made of a reflecting magnetometer, and deflections were observed with a telescope and scale at a scale-distance of 100 cm. Measurements of the horizontal intensity, H, of the earth's magnetism were first made. The results from these determinations by means of the first and second Gauss arrangements were, respectively,

$$H = 0.1724 \text{ cm. g. s.}$$
$$H = 0.1720 \quad \text{"}$$

The freshly magnetized bars were then placed in the second Gauss position relative to the magnetometer, and the angular deflection determined. The specific magnetism, S, was then calculated by the formula

$$S = \frac{r^3 H \tan \phi}{m},$$

where

r = distance from bar to magnetometer = 72.68 cm.
H = earth's horizontal intensity = 0.1722.
m = mass of the bar.
ϕ = angular deflection of magnetometer.

RESULTS.

The mean results of two sets of observations on Group I., and also upon a similar bar of soft tool steel are given in the following table.

GROUP I.

Composition.	Size in cms.	Mass in grams.	$S\,[\text{cm.}^{\frac{5}{2}}\,\text{g.}^{-\frac{1}{2}}\,\text{sec.}^{-1}]$.
Pure Nickel	18 × 2.7 × 0.65	284.5	1.23
Ni + 3% W	" " "	286.5	10.60
Ni + 4% W	" " "	283.5	10.40
Tool Steel	15 × 2.5 × 0.5	159.5	7.46
Ni + 8% W	(Octagonal 13 × 1.5)	144.0	5.25

Group II., of cast bars, gave the following results.

GROUP II.

Composition.	Size in cms.	Mass in grams.	$S\,[\text{cm.}^{\frac{5}{2}}\,\text{g}^{-\frac{1}{2}}\,\text{sec.}^{-1}]$.
Pure Nickel	18 × 1.8 × 1.6	459	1.05
Ni + 1% W	" " "	455	1.92
Ni + 2% W	" " "	454	1.70
Ni + 3% W	" " "	463	1.75
Ni + 6% W	" " "	465	1.15

The bars of both groups were, subsequent to the above observations, completely demagnetized, and then freshly magnetized. New determinations gave the same results as before. The demagnetization was accomplished by placing the bars inside two coils, which were traversed by currents from an alternating dynamo. The coils were then slowly drawn apart, and the bars maintained at a position central between them. After treatment in this manner, they showed no appreciable deflection when placed in position relative to the magnetometer.

The results tabulated indicate that tungsten greatly increases the magnetic moment of nickel, if the alloy be forged and rolled, but on the other hand has but small influence if they be simply cast. Furthermore, changes in the amount of tungsten do not appear to cause corresponding changes in the magnetic properties.

To see whether the remarkable effect in bars 2 and 3, as compared with bar 1, of Group I. was owing to some molecular condition of their surfaces induced by rolling, two bars from the same steel, one rolled and the other pressed, were magnetized and then measured. The ratio of the specific magnetism of pressed to rolled was as 9 to 5, the rolled having the smaller amount. The existing difference, in this case, is probably owing to a difference in hardness, rather than to any molecular condition of the surfaces.

The specific magnetisms of all the bars are small when compared with good steel magnets. Kohlrausch says that good magnets, of common form, should have $S = 40$. The bar of ordinary tool steel, however, retained but 7.46. Still it was soft, and by tempering would doubtless have doubled this value.

If forged nickel and tungsten can be made to maintain a specific magnetism of 10, it will form a useful addition to the resources of physical laboratories. From the high polish of which it is susceptible and its freedom from damaging atmospheric influences, it will be most happily suited for the manufacture of mirror magnets where magnetic damping is to be employed.

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